White Pine Blister Rust and Whitebark Pine Ecosystems in California

Maloney, Patricia [1]; and Dunlap, Joan[2]

[1]Department of Plant Pathology, University of California, Davis, CA,
[2]Sugar Pine Resistance Program, Region 5, USDA Forest Service

Whitebark pine is a key component of California's subalpine forest ecosystems, contributing to species diversity, trophic interactions, wildlife habitat, and hydrologic functions. While the distribution and effects of white pine blister rust (*Cronartium ribicola*) have been well-documented on sugar pine, less is known about the effects of this introduced pathogen on high-elevation white pines throughout California. In 2004 and 2005 the incidence and impact of white pine blister rust (WPBR) on whitebark pine (*Pinus albicaulis*) was assessed in long-term monitoring plots that were established over the species geographic range in California. Plot data included landscape/stand level data as well as individual tree data. The statewide average for rust on whitebark pine was 12%, ranging from 0 to 71%, with the highest levels in the north-central Sierra Nevada (mean = 25%). Cumulative mortality of whitebark pine was low (mean = 1.1%) in the plots, although causes of mortality in these subalpine woodlands may largely be due to drought, mountain pine beetle, and white pine blister rust.

While we do not see the widespread mortality due to WPBR as in other locations throughout the west, WPBR is affecting the demography of white pine populations. Demographic effects include juvenile mortality, lowered recruitment, and reproductive output. These effects can have negative population and genetic consequences, which will influence how whitebark pine populations respond to other stressors, such as climatic warming. Average regeneration of whitebark pine in uninfected plots was 8.8 seedlings (per 0.15 ha) and 6.3 seedlings in plots where WPBR was present. Reproductive output was higher in uninfected whitebark pine populations (40% of trees bearing cones) compared to WPBR-infected populations (34%). More detailed demographic data as well as quantitative measures of cone production are needed to determine the strength of these patterns.

Blister rust infections were not observed on the alternate host *Ribes* in subalpine forests during the study period; annual infections on *Ribes*, however, are often observed in lower montane mixed-conifer forests. A very weak correlation exists between WPBR incidence and percent cover of *Ribes* in subalpine woodlands (r = 0.16) while a much stronger relationship is found between WPBR and *Ribes* cover in lower elevation mixed-conifer forests (r = 0.55), where sugar pine is a component. In this survey, preliminary regression analyses of biotic and abiotic factors gave a strong negative relationship with distance to nearest montane mixed-conifer forests, which may be the source of infective propagules to subalpine woodlands. May relative humidity (positive relationship) was also a good predictor of WPBR incidence, i.e., having a moist spring for infections to occur on *Ribes*, as well as mean September minimum temperature with relatively warmer fall temperatures being a requirement for infections to occur in subalpine forests. Further epidemiological analyses will continue and relate disease incidence to biological and climatological data (PRISM), in order to better understand the epidemiology and disease dynamics of WPBR in whitebark pine forests throughout California.

Interactions among stressors and threats must also be considered e.g., the interaction of climate on WPBR together with mountain pine beetle (MPB) activity, and other anthropogenic influences. Evidence of MPB activity was found in 75% of the whitebark pine plots established, with an average incidence of 7 % (range 0-32%). In high-elevation forests we see evidence of MPB-caused mortality, but at low levels and often associated with protracted drought periods. Once again, these are not at levels of activity seen in other regions of western North America (although there are a few exceptions). So is it a numbers game, in which our region lacks the extensive lodgepole pine forests for large outbreaks and beetle populations to spillover into high- elevation forests or, given the California climatic regime, are whitebark pines in this region relatively more drought tolerant, therefore having a higher threshold before being susceptible to beetle attack? We know little about mountain pine beetle biology and behavior in high elevation forests of California. Clearly, more work is needed in the area of genetics, demography, epidemiology, and MPB ecology to better understand the dynamics of WPBR and other stressors on whitebark pine and how this species will respond to changing environmental conditions in California. Such information would be a valuable asset in developing conservation strategies for maintaining and preserving whitebark pine in the high-elevation subalpine ecosystems.